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of propositions has already reached a high level of development, if we accept Sheffer's analysis of the calculus of propositions, and it is by no means inconceivable that this should make a certain difference in their complete meanings. Moreover, it is not impossible that the notion of a "proposition," in the sense in which this word is used in the "Principia," may itself be capable of analysis in terms of some more simple notion—it is part of mathematical and logical progress not only that our sets of postulates should be rendered more precise by the adjunction of new postulates, but that the "habit" by which we use a set of postulates pertaining to a certain mathematical or logical system we use should be made more unambiguous by the reference of the system as a whole to a finer system, which gives us a smaller opportunity for ambiguity in the habit by which we use its postulates, as a center of orientation, as it were. There is no need, then, of supposing that even the axioms of the "Principia" or any similar set we shall ever come to are not subject to further analysis, and that we have an absolutely adequate knowledge of the meaning of any logical proposition whatever. Hence, although our degree of uncertainty in logic is so infinitesimal as not to enter at all in the allowance we make for error in our scientific reasonings, we have no reason to suppose it is altogether absent.

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A STUDY OF AN IMAGERY TEST

IN Dr. Mabel Fernald's monograph, "The Diagnosis of Mental Imagery," the following test is described. Long words, such as somnambulist, symmetrical, etc., were pronounced to subjects who were then required to spell them backwards orally, and to report upon the process, noting especially any imagery which appeared to help in the performance of the task. The time taken to spell the word was noted on a stop-watch. Dr. Fernald writes:

"In general, we seem justified in saying that the results indicate that the rapidity of this form of spelling is favored by the ability to summon clear, vivid, and stable visual images of the words without a very great need for accessory factors. . . . We can not rely upon this as a purely objective test, since it would lead us into many errors of diagnosis. As a partially objective test, however, lending confirmation to the reports of the subjects, it would seem to be of greater value."

This test, though similar in principle to the Binet letter squares in which letters must be learned in a given position and then reproduced in some other designated order, and though it is also like the

Binet eight-year-old intelligence test which requires the subject to count backwards from twenty, has an advantage over these two. Fernald's test uses material which is already mastered in its original form, *i. e.*, the forward spelling of the word, and which is available in large quantities, so that the subject's reaction can be taken repeatedly. However, in a recent paper, Dr. Clara H. Town has called in question the validity of the test, on the basis of an experiment which she made upon six blind and six seeing persons. She says: "The tests in question have little or no value as objective tests for determining the use of visual imagery by a given individual."

A reliable diagnostic test of imagery seems to the present writer very important from a pedagogical point of view. A teacher needs to know the mental traits of the children with whom he deals, and children themselves may with profit be made aware of their own mental habits and of the changes which they might make in them. Hence it seemed worth while to gather more data on this test. I tried it with twenty-five adults and twenty-five children. The adults were all women, most of them college students between twenty and twenty-five years of age. The children were all girls between the ages of ten and twelve.

To adapt the test to these children shorter words were used than those in Fernald's list, and in order to cut down the rather large variations which she got, words of equal length were given. The first series consisted, then, of these fifteen words: *family, return, church, person, finger, pounds, handle, before, honest, figure, bundle, glance, always, pretty, custom.* Though these words are equal in length they proved to be somewhat variable in difficulty. The middle reading for the adults ranges from 4 seconds for the word *pretty* to 5.8 seconds for the word *church.* For the children the range lies between 6.4 seconds for *person* and 9.2 seconds for *custom.* The order of difficulty is not the same for adults and children, the correlation between the two orders being $+.36$. A second series was also tried, containing fifteen words of nine letters each, as follows: *following, constancy, treatment, carpenter, different, respected, fifteenth, gentleman, everybody, separated, intensity, merchants, sometimes, daughters, Wednesday.* In cases where the words were unfamiliar to the children certain substitutes were given. These were, *beautiful, contained, selection,* and *relations.* I have not computed the relative difficulty of these words, but they, like the short list, would undoubtedly show differences, and I think this test would be much improved by choosing words from a standardized list such as Ayres has now published in "A Measuring Scale for Ability in Spelling."

At the beginning of each test the subject spelled a few preliminary words backwards and was questioned as to how she went about the task. The attempt was made to elicit spontaneous and circumstantial comments upon the imagery, and to avoid suggesting particular kinds of imagery. The reliability of the children's reports may seem especially open to question. My plan was, from my previous knowledge of these children and from preliminary questioning, to hazard a guess as to the child's imagery, and then to see whether she would make a statement and hold to it in the face of a contrary suggestion. This I found that they would often do. For example, to one whom I believed to have little visual imagery I said, "Do you seem to see the word?" She said "No I don't see it at all; I think it." "Don't you see it as if it were written or printed out?" "No, I just think it—like a voice." If I made a wrong guess and the child agreed with my suggestion, I then tried to get some detail about the image which should seem to mark it as genuine. For instance, I asked one child about her sound images, whose voice they were like. She answered, "Why it's a mixture of mother's voice and mine." Answers like that I take to be genuine. Judging, then, partly by the child's assured statement, partly by the spontaneity and naïveté of the statement, and partly by incidental signs, as when I heard the whispered spelling of the word forwards, or saw the child writing in the air with her hand, I felt some confidence in the accuracy of the children's introspections.

The kinds of imagery noted are designated as follows:

Vis. whole. Some persons were able to apprehend the word as a whole picture, and to spell it off as if reading the letters backwards from a printed page. They were not aware of depending on other cues.

Vis. part. Subjects reported fragmentary visual imagery of words. Sometimes it appeared syllable by syllable, sometimes in arbitrary groups, occasionally even letter by letter. Under this rubric are included those, also, who used visual imagery, but who did not see the word certainly as a whole.

Mixed. Those subjects are here counted as mixed in type, *a,* who use some visual images, but who change cues from word to word, *b,* who for each word use a combination of cues including the visual. Among them are certain cases in which the subject depends upon a visual image, but finds it necessary to pronounce the word in order to summon the picture.

Doubtful. Cases in which the subject could give no conclusive account, and cases in which I could not be sure that she was not influenced by the form of my question, are recorded as *d.*

Aud. and *art.* refer to those who used characteristically auditory or articulatory images.

Gr. mot. means grapho-motor, and the class *non-vis.* is used to cover the cases in which the subject could not specify her method further than by saying that it was certainly not visual. This term is not, therefore, exclusive of auditory, articulatory, etc., cases.

The distribution of the subjects among these imagery classes is as follows in Table I.

TABLE I

		Vis. Whole	Vis. Part	Mixed	D.	Aud.	Art.	Gr. Mot.	Non-vis.
Short words.	Adults.....	8	4	7	0	0	2	0	4
	Children.	5	4	3	3	2	6	1	1
Long words.	Adults.....	4	5	5	6	0	2	0	3
	Children.	2	2	3	5	2	5	1	1

The distribution of subjects according to speed is given in Table II. The time was noted on a stop-watch. The median of the fifteen reactions gives the subject her rank. Thus the number 9, Table II., means that there were nine adults whose median reactions took from three seconds up to (but exclusive of) four seconds.

TABLE II

Time	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	...	22	23	...	31
Ad...	0	9	7	4	2	2	1	0	0	0													
Ch...	0	0	1	1	4	5	5	4	2	0	1	0	0	1	0	0	0	0	.....	.....	1		
Ad...	0	0	0	3	5	4	4	2	0	2	0	2	0	0	3								
Ch...	...	...	...	...	...	...	...	...	2	3	5	0	2	2	0	3	0	1	.....	1	.....	.....	1

The children here show a normal distribution, whereas the curve for the adults is skewed to the left in the short series. Reference to the preceding table shows that whereas the visual and the non-visual methods are fairly evenly distributed among the children, the visual methods clearly outweigh the non-visual among the adults. In other words the visual image seems to go with the better speed. The factor of age might account for the absolute differences in speed, but it can not with certainty be made to account for the form of the distribution.

Table III. gives the median in seconds with its probable error for each subject, the type of imagery characteristic of the subject in this test, and the number of errors for the whole series. Table III. gives the records for the short words, Table IV. for the long words.

TABLE III

Adults					Children				
Subject	M	P. E.	Imagery	Errors	Subject	M	P. E.	Imagery	Errors
1	3	.6	vis. whole	0	1	4	1.2	vis. whole	0
2	3	.8	vis. whole	5	2	5	1	mixed	0
3	3.2	.4	vis. whole	0	3	6	1	aud.	3
4	3.2	.6	art.	0	4	6	1	vis. whole	1
5	3.4	.4	vis. whole	0	5	6.4	1.4	art.	0
6	3.6	.4	non-vis.	0	6	6.4	1.4	vis. whole	1
7	3.6	.6	vis. whole	0	7	7	1	d.	3
8	3.8	.6	vis. whole	2	8	7	1.2	art.	3
9	3.8	.6	mixed	0	9	7	1.3	vis. whole	0
10	4	.6	mixed	2	10	7.2	2	non-vis.	0
11	4.2	.6	vis. whole	0	11	7.6	1.2	vis. part	2
12	4.4	.8	non-vis.	1	12	8	1.2	vis. whole	2
13	4.6	.6	mixed	1	13	8	1.4	mixed	3
14	4.8	.6	mixed	0	14	8	2.4	d.	0
15	4.8	.8	vis. whole	0	15	8.2	3	vis. part	5
16	4.8	.8	vis. part	2	16	8.6	2.4	d.	0
17	5	.4	mixed	0	17	9	1.4	vis. part	1
18	5.2	1.2	mixed	2	18	9.2	.2	art.	3
19	5.4	.6	vis. part	1	19	9.2	3.2	art.	7
20	5.6	.6	vis. part	2	20	9.4	2	vis. part	1
21	6.4	1.4	mixed	1	21	10	1	gr. mot.	1
22	6.6	1.2	non-vis.	2	22	10	1.6	art.	1
23	7	.6	vis. part	1	23	12	2.6	aud.	5
24	7	1	art.	1	24	15.8	2	art.	1
25	8.2	2.4	non-vis.	7	25	23.4	12.6	mixed	11

TABLE IV

Adults					Children				
Subject	M	P. E.	Imagery	Errors	Subject	M	P. E.	Imagery	Errors
1	5.4	.6	vis. whole	1	6	10.2	1.2	vis. whole	3
6	5.6	.6	non-vis.	2	1	10.6	4	vis. whole	0
5	5.8	.8	vis. whole	0	2	11	3.2	mixed.	1
7	6	.6	d.	1	11	11.2	2.4	d.	2
9	6	1.4	mixed	0	5	11.8	2.2	art.	1
4	6.4	.8	art.	1	7	12	1.4	mixed	0
8	6.4	.8	vis. whole	5	3	12	1.4	aud.	0
3	6.6	1.4	vis. part	1	9	12.2	1.4	vis. part	0
11	7	1	vis. part	0	10	12.2	2.8	non-vis.	5
15	7	1.2	vis. whole	0	16	12.6	2	d.	1
2	7	1.4	mixed	5	4	14.2	3.4	vis. part	0
10	7	1.8	mixed	0	14	14.4	4	d.	3
12	8	1.2	d.	1	18	15	1.6	art.	1
14	8	1.8	mixed	2	8	15	3	art.	2
16	8.6	1.4	vis. part	0	21	17	2	gr. mot.	0
17	8.8	1.4	mixed	1	23	17.2	2.8	aud.	3
19	9.6	1	vis. part	3	22	17.4	4	art.	5
13	9.8	1.8	vis. part	3	20	19	2.8	mixed	5
21	11	3	d.	3	15	22.2	5.2	d.	7
20	11	3.6	d.	3	24	31.6	7.6	art.	4
18	13	3.2	d.	3	17	31.8	12.4	d.	2
24	13.2	2.6	art.	0					
22	16	1.8	non-vis.	2					
23	16	3.6	d.	3					
25	16.4	5.4	non-vis.	5					

From these tables it appears that with short words the middle reading for adults who use whole visual images is 3.5 seconds; P.E. .4; for those who use other forms (treating them as one class) 5 seconds P.E. 1. For children who use whole visual images the figures are 6.4 seconds, P.E. .6, and for the others 8.4 P.E. 1.3.

The long words give for the adults, vis. whole 6.1, P.E. .5, others, 8.6, P.E. 2.2. For children vis. whole 10.4, P.E. 4; and others 15, P.E. 2.8.

The average errors are, with short words, for adults vis. whole .8; others 1.35; for children vis. whole .8; others 2.5. With long words, adults, vis. whole 1.5; others 1.8. Children vis. whole 1.5; others 2.2. Thus there is an advantage throughout in favor of the vis. whole group. Those who use fragmentary visual imagery seem to be no better off than the non-visualizers.

The Effect of Practise. The medians of the first five, the middle five, and the last five reactions were noted for each subject. The result is that no clear practise effect is discernible. Of the adults in the short series 10 grew worse, 4 remained the same, and 11 grew slightly better. Of the children 18 grew slightly worse, 2 remained the same, and 5 improved slightly. In the long series 12 adults improved and 13 deteriorated, 10 children improved and 11 deteriorated. The changes were slight and in general are smaller than the probable error. This result speaks in favor of the usefulness of the test, as it is not likely to be vitiated by the fact that many children play games or use codes in which spelling backwards is a feature.

Conclusion. It is desirable that the test be tried with more subjects, including men and boys, and also with a list of more perfectly standardized words. The present results seem to me to support Dr. Fernald's estimate of the test as quoted above. Dr. Town's method may account for the difference in her results. In her report she uses "seeing subjects" as the equivalent of "visualizers." The assumption that all seeing persons use visual imagery in a test like this is entirely unwarranted, and it makes Dr. Town's results quite meaningless, it seems to me, so far as the imagery problem is concerned. It should be said, finally, that although this test may prove to be a useful accessory in classifying persons according to their imagery, yet it does not indicate that a person belongs to such and such a general imagery type. In other words a person may be a visualizer in the kind of performance which the test represents, but may be something different in other enterprises.

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